Three Phase BLDC Motor Driver

Mini Drive 100 1E User Manual

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Contents

Contents i

List of Figures ii

List of Tables iii

1 Introduction 1

2 Identification of Components 2

2.1 List of Items Included in the Kit 3

3 Maximum Limits and Typical Rating 3

4 Controller Dimensions 5

5 Connections 6

5.1 Supply Voltage Connections 7

5.2 Hall Effect Sensor Connections 7

5.3 Motor Phase Connections 7

6 Operation 9

6.1 Tuning the PI Controller Gains 10

6.2 Adjusting the Motor Speed 11

7 Features and Caution 11

8 Warranty 12

Index 14

List of Figures

1 Top view of the board 1

2 Identification of components on the drive . . . 2

3 Controller dimensions (x, y) 5

4 Controller dimensions (z) 6

5 Mini drive running a fan load 9

List of Tables

1 Components of the board 3
2 Items included in the kit 4
3 Drive rating 4
4 Hall sensor connector color code 8
5 Motor phase connections 8
6 Motor and Hall sensor phasing 8

1 Introduction

Thank you for using our product. It is highly recommended that you go through this user manual to understand the safety limits and rating limits so as to not damage the motor or drive. The drive may be permanently damaged if used improperly.

The Mini Drive 100 1E is a robust, high quality, three phase brushless DC motor drive based on Hall effect sensor feedback and provides six-step commutation. It has been designed by Vita and is a result of our expertise in BLDC motors and controls. It is a low power unit with integrated mosfets in the controller IC and is capable of supplying more than 1 A at a maximum voltage of 32 V. The controller has the ability to switch off and turn on the motor, change the direction of rotation, enable set-point speed reference for closed loop speed control, and provide diagnostic warning under fault conditions.

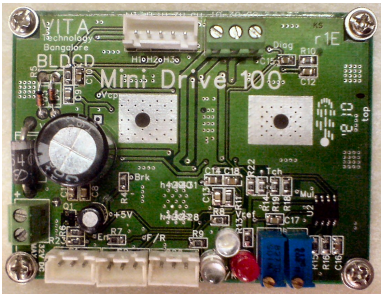

Figure 1: The top view of the board. Both sides of the board are populated with components.

The drive is specially designed for small motors that consume less than 25 W continuously and up to 40 W for a few seconds of intermittent duty. The maximum input voltage is 32 V dc.

It is suitable for small brushless DC motors that drive pumps, fans, and other such applications.

Customized versions of the drive with additional controls can be provided by Vita if required.

2 Identification of Components

Fig. 2 shows the list of components of the drive. Later sections describe in detail the method of connecting the motor and various other parts to the controller PCB.

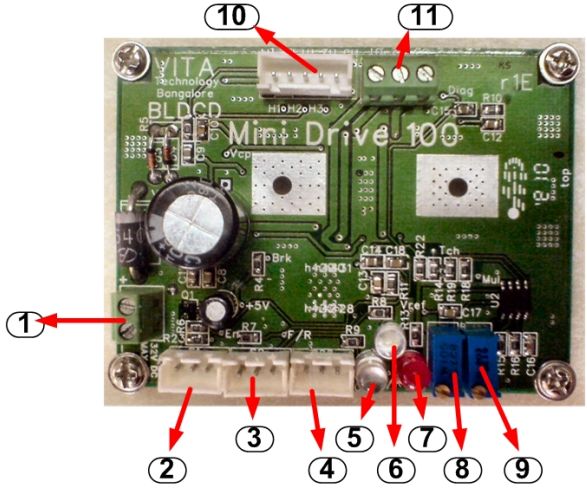

Figure 2: Identification of the components on the board of the drive. Please refer to table 1 for the complete listing.

Table 1: List of important components located on the PCB.

Item number	Description
1	Supply voltage connector (Note polarity on) PCB when connecting.)
2	ON/OFF switch header (3 pin)
3	Forward/Reverse switch header (3 pin)
4	Speed control potentiometer header (3 pin)
5	ON/OFF LED (green)
6	Forward/Reverse LED (blue)
7	FAULT LED (red)
8	Integrator gain control (Pot)
9	Multiplier gain control (Pot)
10	Hall effect sensor header (5 pin)
11	Motor phase connectors

2.1 List of Items Included in the Kit

Table 2 lists the items provided in the kit. Please make sure you have all the components before attempting to mate the motor and controller board.

3 Maximum Limits and Typical Rating

Table 3 shows the maximum and typical values of the drive controller. Please note that the maximum current is only for intermittent duty and the drive should not be driven for more than a few seconds at the extreme end of the current value. The on-resistance of the power devices inside the IC will produce high heat loss which combined with the switching losses may per-

Table 2: List of items included in the standard Mini Drive Kit

#	Item	Quantity	Description
1	Mini drive PCB	1	Motor controller board with heat sink mounted on top side.
2	User manual	1	This manual may be downloaded if not availabe with the kit.
3	Switch interface	2	For the ON/OFF and F/R switches. 300 mm length 3 wire cable with switch on one side and male connector on the other end.
4	Potentiometer interface	1	10 k, 10 turn pot on one end of 3 wire cable with male connector at the other end (300 mm length).
5	Hall sensor interface	1	600 mm, 5 wire cable with 5 pin female connector at one end.
6	Mounting nuts	4	Nuts to lock the mounting screws.

manently damage the control board.

Table 3: Rating of the drive, typical and maximum values.

Description	Min	Max	Typ	Units
Supply voltage, V_s	8	32	12-24	V dc
Supply current, I_s	10 m	2.0	< 1	A dc
Ambient temperature, T_{op}	5	45	25	^{o}C
Speed with 8 pole motor	-	30k	-	rpm

Please ensure that the typical current rating is not crossed and the maximum voltage and temperature ratings are honored at all

times. Load currents greater than 1 A can be obtained if there is no chopping. **Please ensure that the motor rated torque and rated speed can be fully obtained at rated voltage without PWM for current regulation.** This way the full power spectrum of the IC can be used. If the motor used is of a higher voltage and speed rating, the duty cycle reduction of the PWM may cause severe overheating of the IC which will result in severe degradation of the available output power. The typical input power for continuous operation is 25 W.

4 Controller Dimensions

The board size is approximately 77 x 57 mm, it is about the size of a business or credit card. Fig. 3 and 4 show the top view and side view of the board.

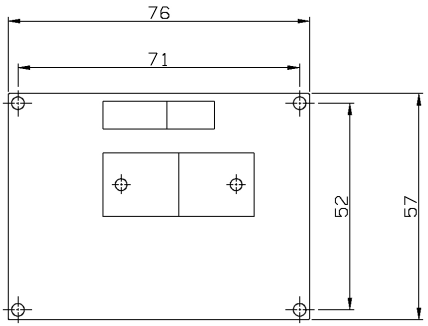

Figure 3: All dimensions are in mm

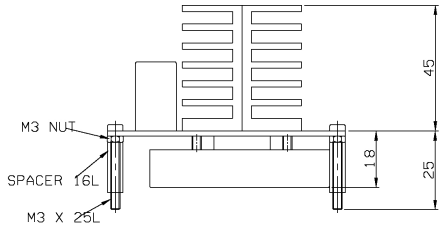

Figure 4: All dimesnions are in mm. Two heat sinks are used, one set on the top side and a single one on the bottom side.

5 Connections

This section describes the steps to connect the switches and potentiometer to the PCB.

1. Mount the 2 switches and the potentiometer on a suitable mounting plate and tighten the locking nuts.
2. Attach one of the male connectors of the switch assembly into the ON/OFF female connector on the PCB. This becomes the ON switch.
3. Attach the male of the second switch assembly into the F/R female connector on the PCB. This becomes the direction control switch.
4. Attach the male connector of the potentiometer assembly into the female marked 'Speed' on the board. Make sure that the potentiometer is turned fully CCW when looking at the shaft ensuring zero speed command. (CW- Clockwise, CCW- Counter Clockwise)

The above instructions take care of switching the drive on and off, changing directions, and adjustable speed control.

5.1 Supply Voltage Connections

Connect two wires with appropriate color coding and cross sectional area (these two wires are not supplied as part of the kit) to the supply voltage connector. Make sure that the polarity of the positive and return lines match with the drive.

5.2 Hall Effect Sensor Connections

Table 4 shows the color code for the Hall sensor connector with the 600 mm cable assembly. Please ensure that the colors and description in the table is followed when soldering the wire ends to the Hall sensors. The control board contains the required pull-up resistors. The Hall sensor spacing should be 120 electrical degrees. This controller cannot work with 60 electrical degree spaced Hall sensors. The controller has been verified using bi-polar Hall sensors with internal Schmidt trigger. Please do not use analog Hall sensors as the controller will not work. A dedicated regulator on the PCB supplies 5 V dc to the Hall effect sensors.

5.3 Motor Phase Connections

Table 5 shows the sequence of connecting the three phases of the motor to the control board. For proper operation of the motor-controller combination, the back emf generated by the phases must be in phase with the Hall effect sensor outputs. See table 6.

Table 4: The color codes for the Hall sensor connector. These are marked on the silk screen of the PCB.

Wire	Wire color	Designation
1	Blue	H+
2	Green	H- (gnd)
3	Yellow	H3
4	Orange	H1
5	Brown	H2

Table 5: Motor phase connections. These are marked on the silk screen of the PCB.

Wire	Connector	Motor phase
1	O1	C
2	O2	B
3	O3	A

Table 6: Motor and Hall sensor output phasing. The table indicates that H1 will be positioned such that it is in phase with the back emf generated by phase CB in a wye or delta connected motor. Sensor H2 will be in phase with phases BA, and sensor H3 with phases AC. If this is not implemented, the drive will not work dependably.

Item	Hall sensor	Motor phases
1	H1	CB
2	H2	BA
3	H3	AC

6 Operation

The motor is operated after the power supply connection has been made and the supply voltage is turned on. Even when the motor is not operating and supply is available, the drive is in sleep mode. It is turned on when the on/off switch is moved to ON position. If the motor does not rotate, slowly move the speed potentiometer knob CW to increase the speed command. The motor will start to rotate and increase its speed. When the potentiometer has turned CW fully, the motor should be running at its maximum speed with no PWM to control speed. If the motor runs and it appears to be not fully controllable, it means that the drive-motor combination needs tunings.

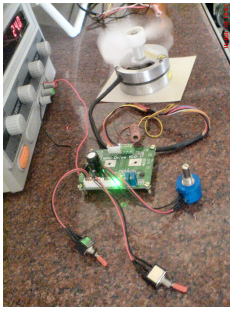

Figure 5: The image shows the drive running a small fan load. The speed can be controlled by using the potentiometer, the switch on the left is to turn on or off the motor, the switch on the right is to change the direction of rotation. The Hall sensors inside the motor are fed to the controller using the supplied 5 pin cable with the 5 pin male attached to one end (item 5 in kit).

6.1 Tuning the PI Controller Gains

The drive is tuned at our factory using a small BLDC motor. However it may have to be again tuned when the inertia of the rotor-load combination changes drastically. Closed loop speed control is based on proportional-integral feedback.

1. Rotate the multiplier gain potentiometer by using a small screwdriver in the CW direction until you reach the end. Refer to Fig. 2.
2. Now rotate the speed potentiometer fully CW to maximum speed.
3. Rotate the integrator gain control pot in the CW direction until the motor fully stops after decelerating. The pot may have to be rotated slowly when the rotor begins to slow to allow for inertial effects to die out.
4. Now, slowly rotate the integrator pot in the CCW direction until the motor starts and accelerates to full speed. Rotate a further half turn. The motor-drive is tuned now.
5. If the motor does not slow down, then rotate the integrator potentiometer back fully in the CCW direction. Rotate the multiplier pot just 1 turn in the CCW direction and then repeat from step 3 until the motor-drive combination is tuned.

It is recommended that the tuning of the motor be done at low voltages before tuning at higher voltages.

6.2 Adjusting the Motor Speed

If required, the tuning described in the previous section has to be performed. After which, the speed potentiometer can be rotated back in the CCW direction to reduce the speed. When it is rotated fully in the CCW direction, the motor should stop. When it is rotated fully in the the CW direction, the motor should reach maximum speed. At any midway point, say 50% speed, if the supply voltage is reduced, it should be seen that the motor stays at almost the same speed up to a lower point after which the speed control is lost. On the higher side, the controller should maintain the same speed all the way up to 32 V dc.

7 Features and Caution

The drive is protected against reverse voltage polarity via a series diode. It is also protected against voltage transients by using a parallel zener diode.

The fault indicator (red LED) will light up when:

- The internal temperature of the IC is excessive
- An over-current situation has occurred

When the fault indicator lights up, the power switches of the three phase bridge of the controller are automatically disabled. If the fault indicator lights up, the drive must be switched off immediately and the temperature of the IC checked.

Important: Never change the direction of rotation when the motor is already running in any one direction. The following instructions must be followed to prevent permanent drive failure

due to over-current conditions that exist in dynamic direction reversals of the motor:

1. Switch off motor by using the ON/OFF switch
2. Wait for the rotor or load to completely stop rotating
3. Change the direction with F/R switch
4. Switch on the motor now using the ON/OFF switch

The blue LED indicates operation in one direction, it is not lit while operating in the reverse direction.

The drive is not coated with any protective coating after assembly. Please ensure that no moisture, liquid, or any conducting fluid or components come in contact with the PCB. Periodically please clean the board with low pressure compressed air to remove dirt and dust that may cause faults and perhaps permanent drive failure.

8 Warranty

No modification of any sort of the PCB is permitted without written authorization from Vita.

Each unit is completely tested at our factory after assembly of the PCB with a brushless DC motor and data recorded with the serial number. The switches and potentiometer that are included in the kit are used during testing. No defective components will be shipped out. As the drive can be damaged if not used with caution and if used outside the envelope that it has been designed to operate in, and the cause cannot be verified after fail-

ure, there is no warranty for the drive implied or supplied. In no case will a free replacement PCB be provided.

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Index

5 V dc, 7

caution, 4, 11
CCW, 6
coating, 12
components, 2
connections, 6
connector, 2
connectors, 2
copyright, 13
CW, 6

delta, 7
dimensions, 5
direction of rotation, 6, 11
dust, 12

Hall sensor, 7
Hall sensor requirements, 7
Hall sensors, 7
header, 2

identification, 2
inertia, 10
introduction, 1

kit, 3

LED, 2
limits, 3

motor phase, 7
motor requirements, 5

off, 6
on, 6
operation, 9

phasing, 7
pull-up resistors, 7
PWM, 9

rating, 3

Schmidt trigger, 7
size, 5
speed control, 11
supply voltage, 7
switch, 2

three phase brushless motor, 1
tuning, 9, 10

values, 3

warning, 11
warranty, 12
wye, 7